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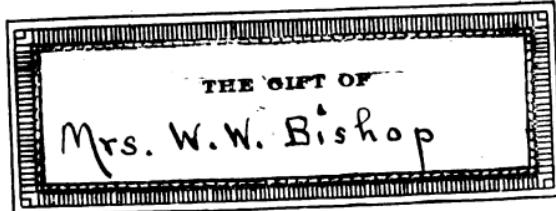
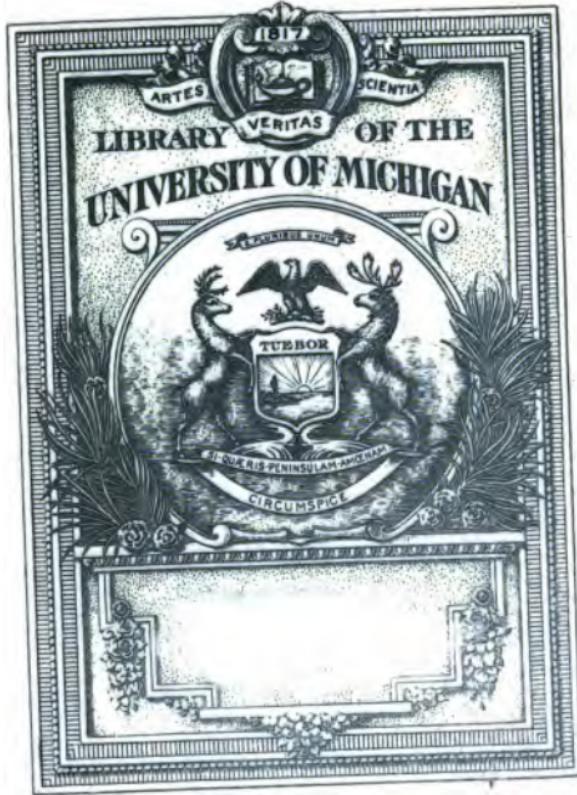
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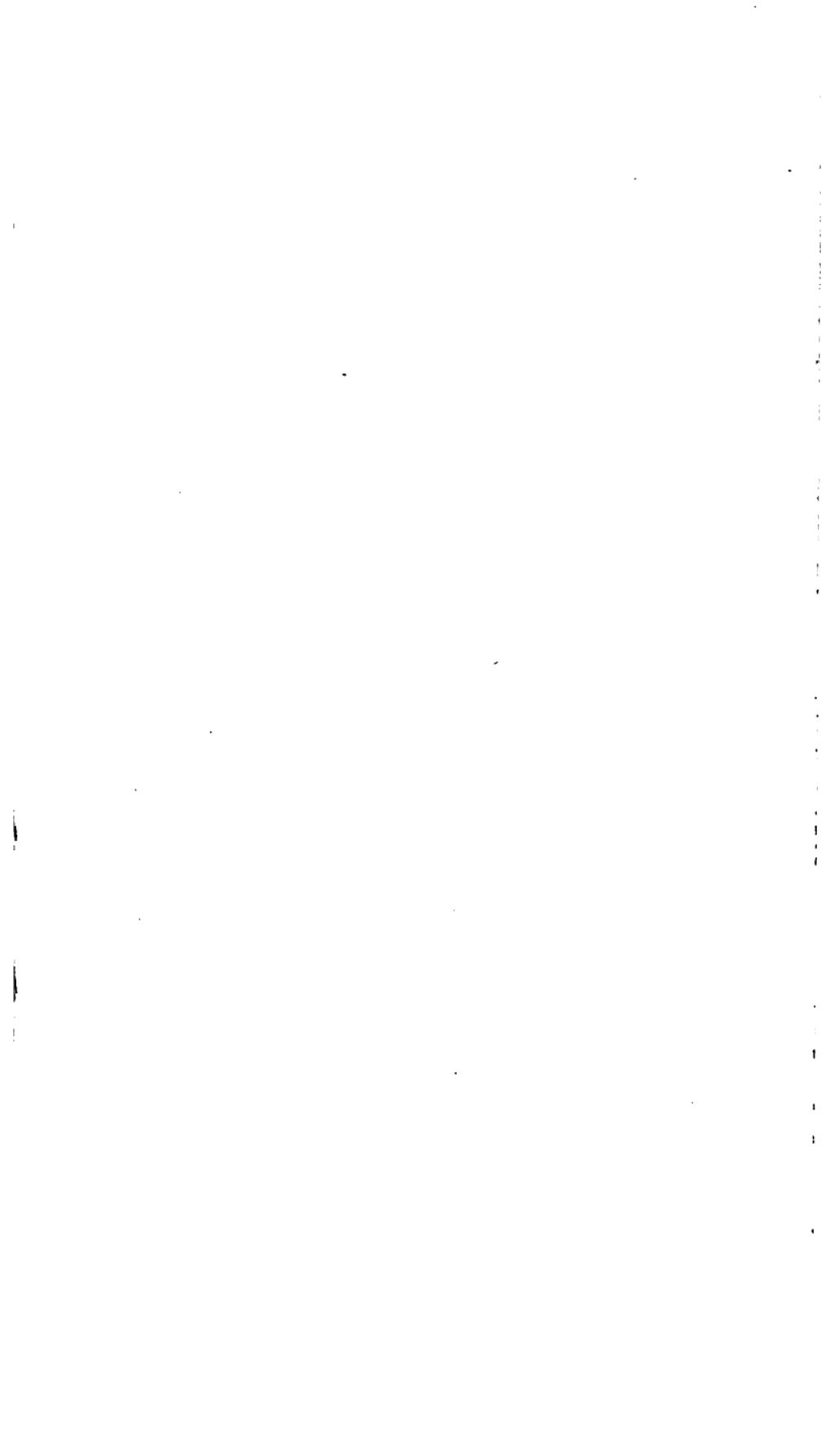
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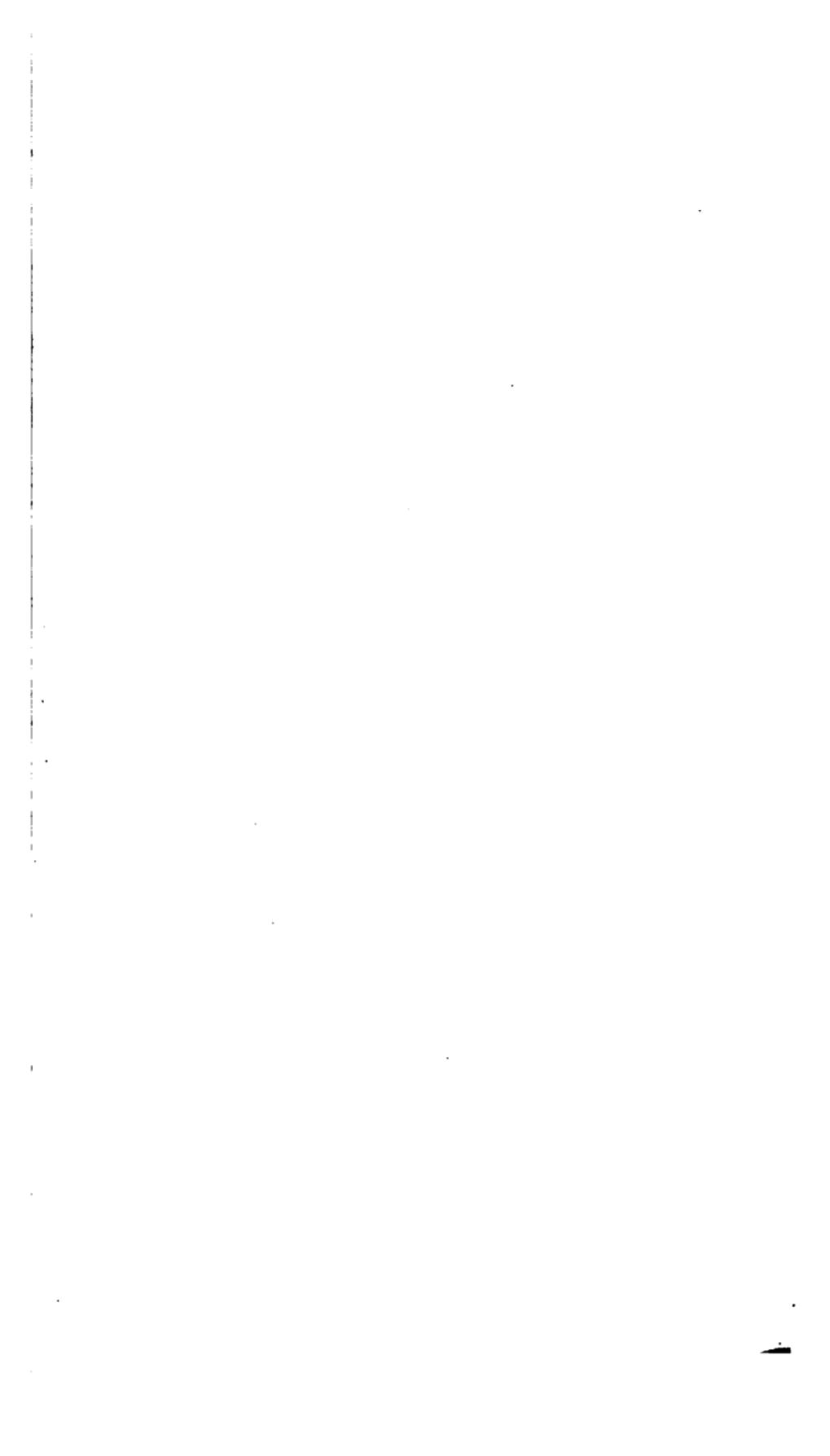
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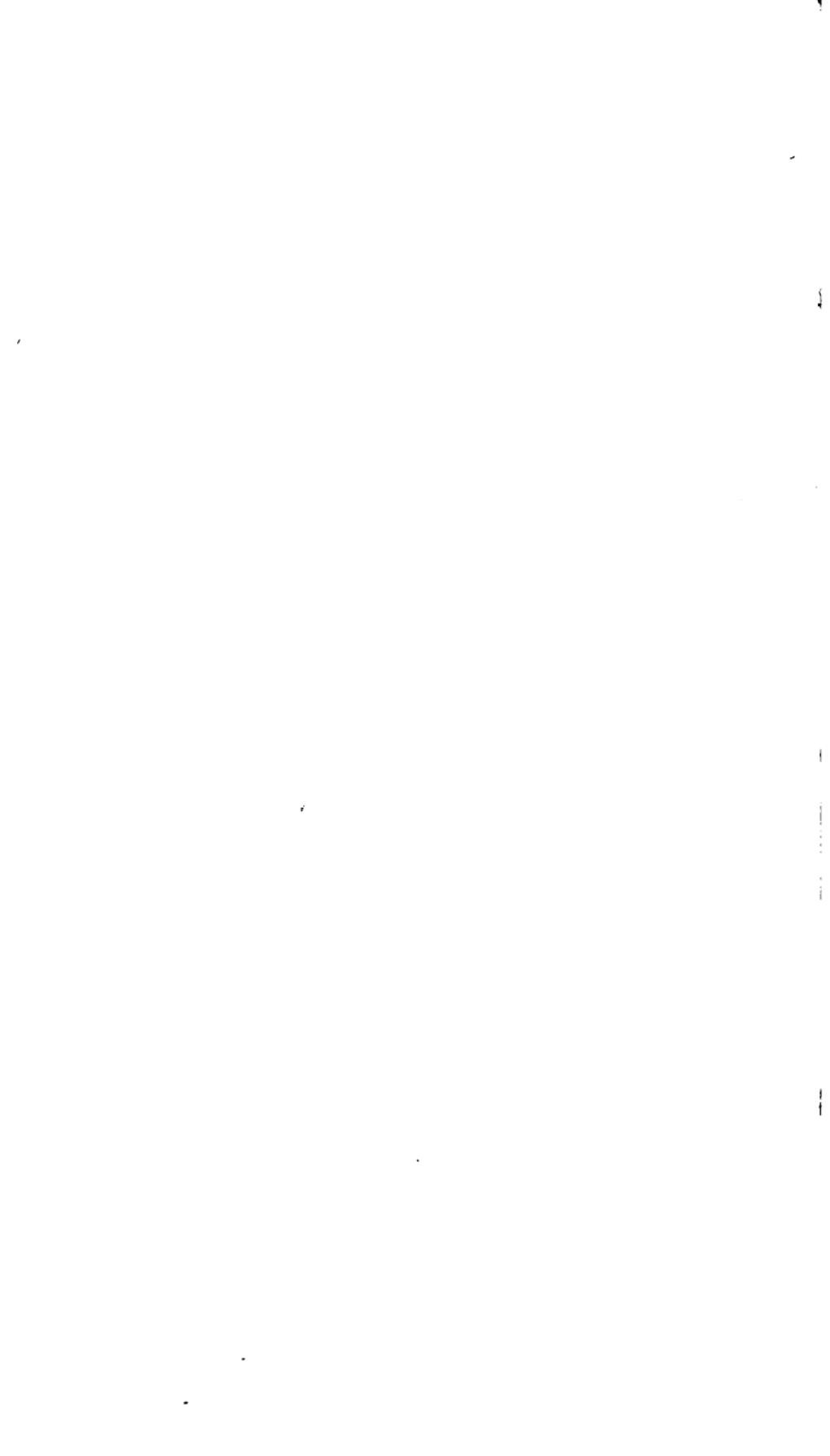
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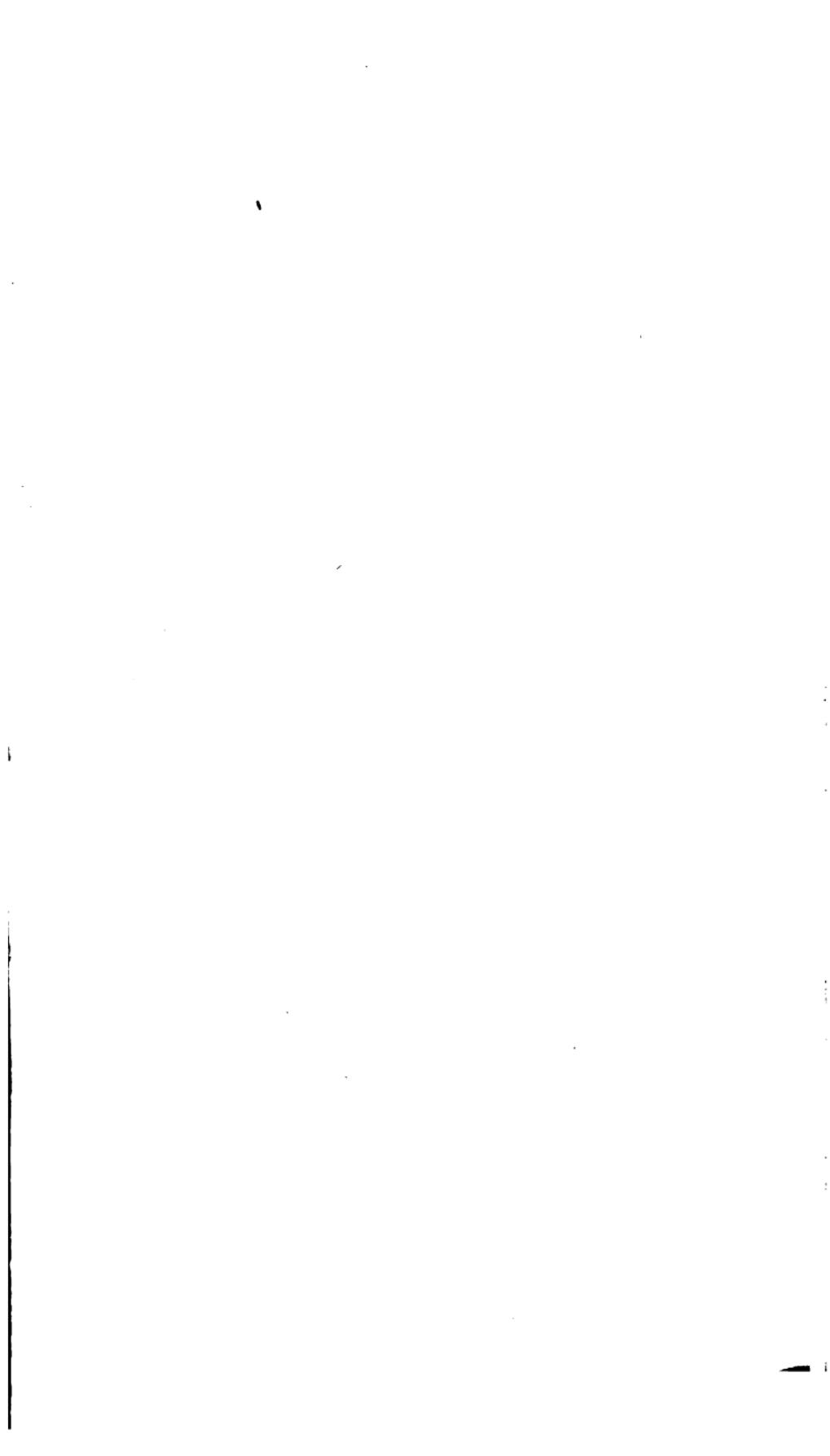


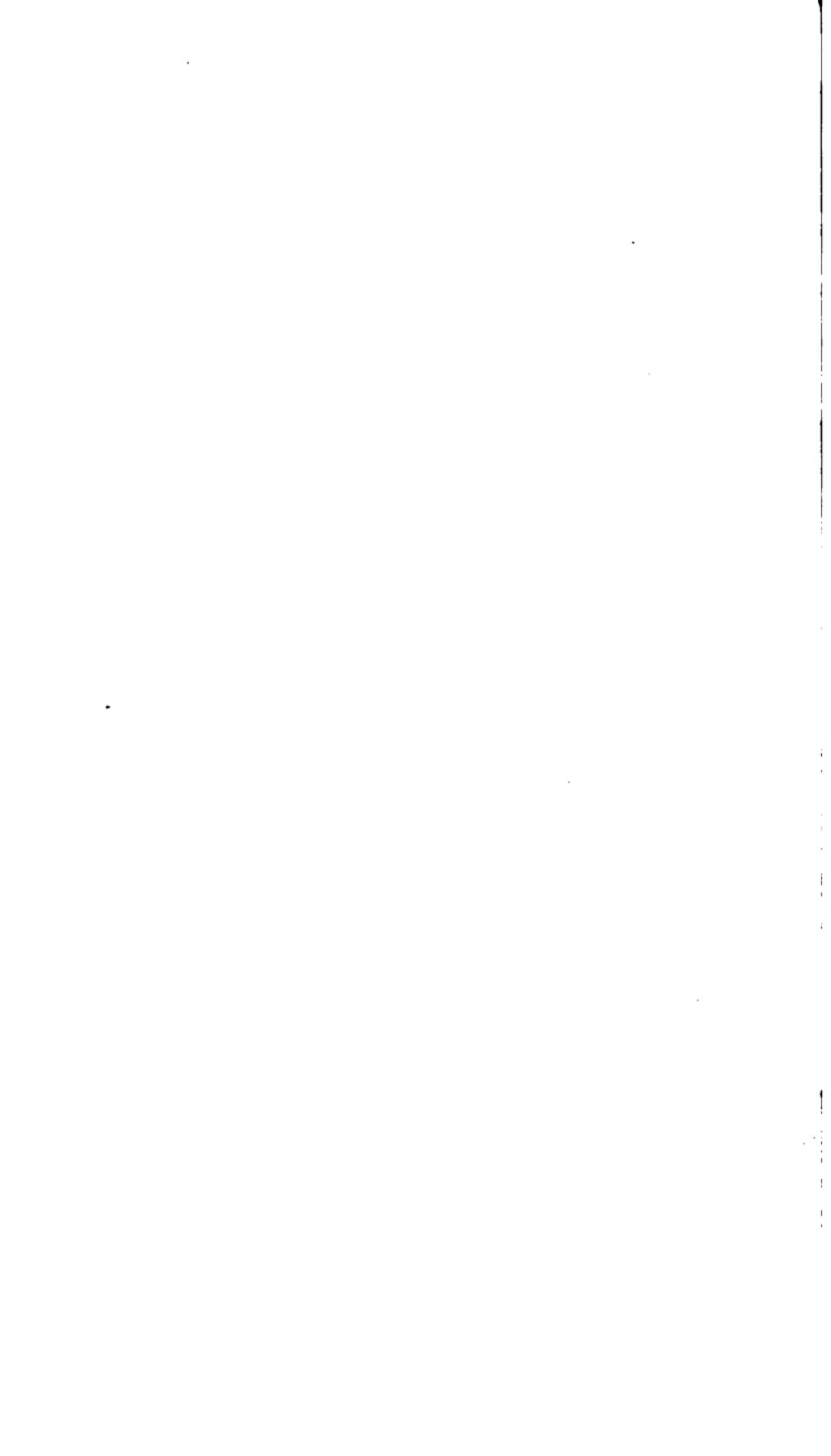
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THE FIREFLY'S LIGHT

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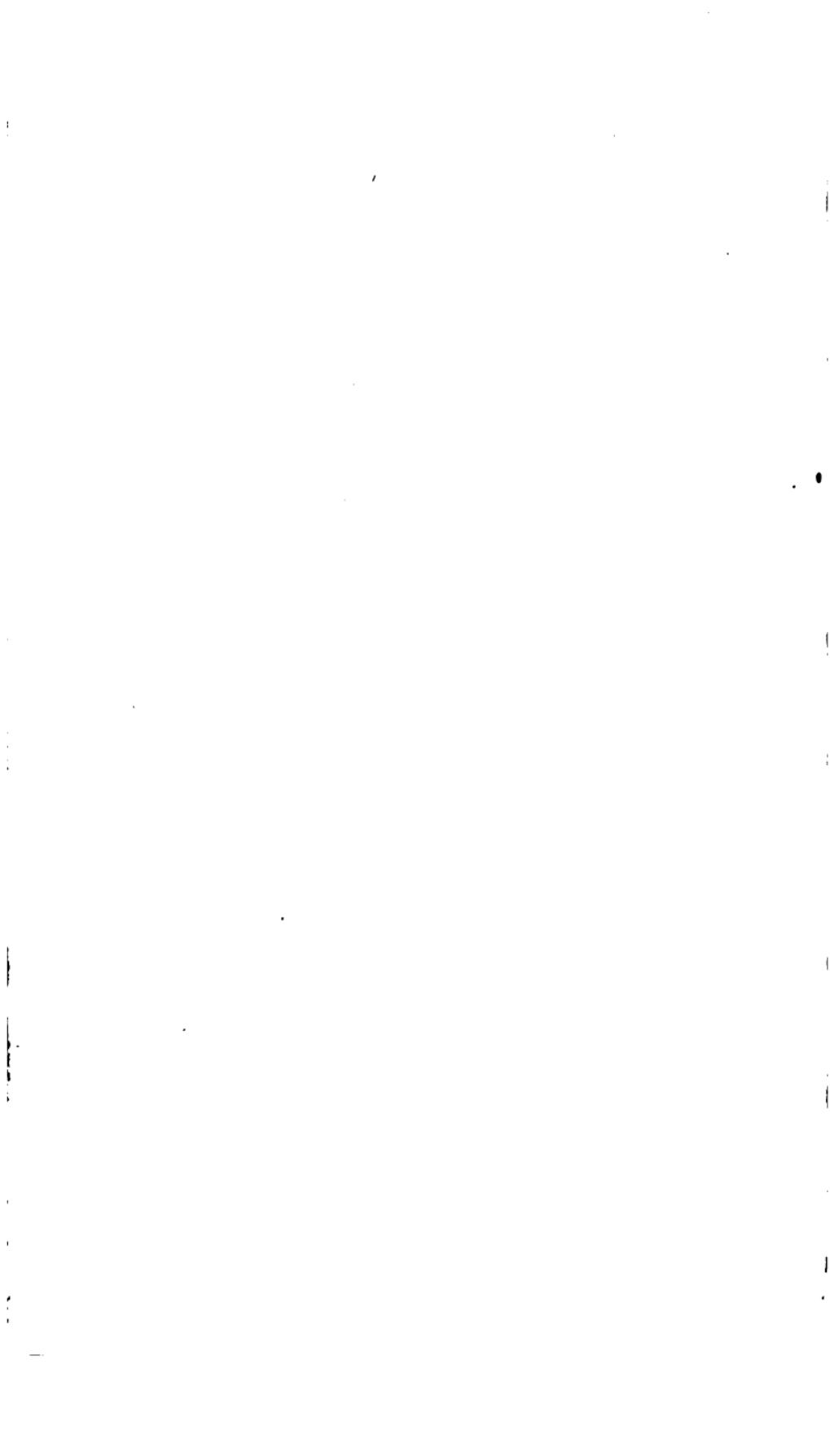
THE FIREFLY'S LIGHT

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The Firefly's Light

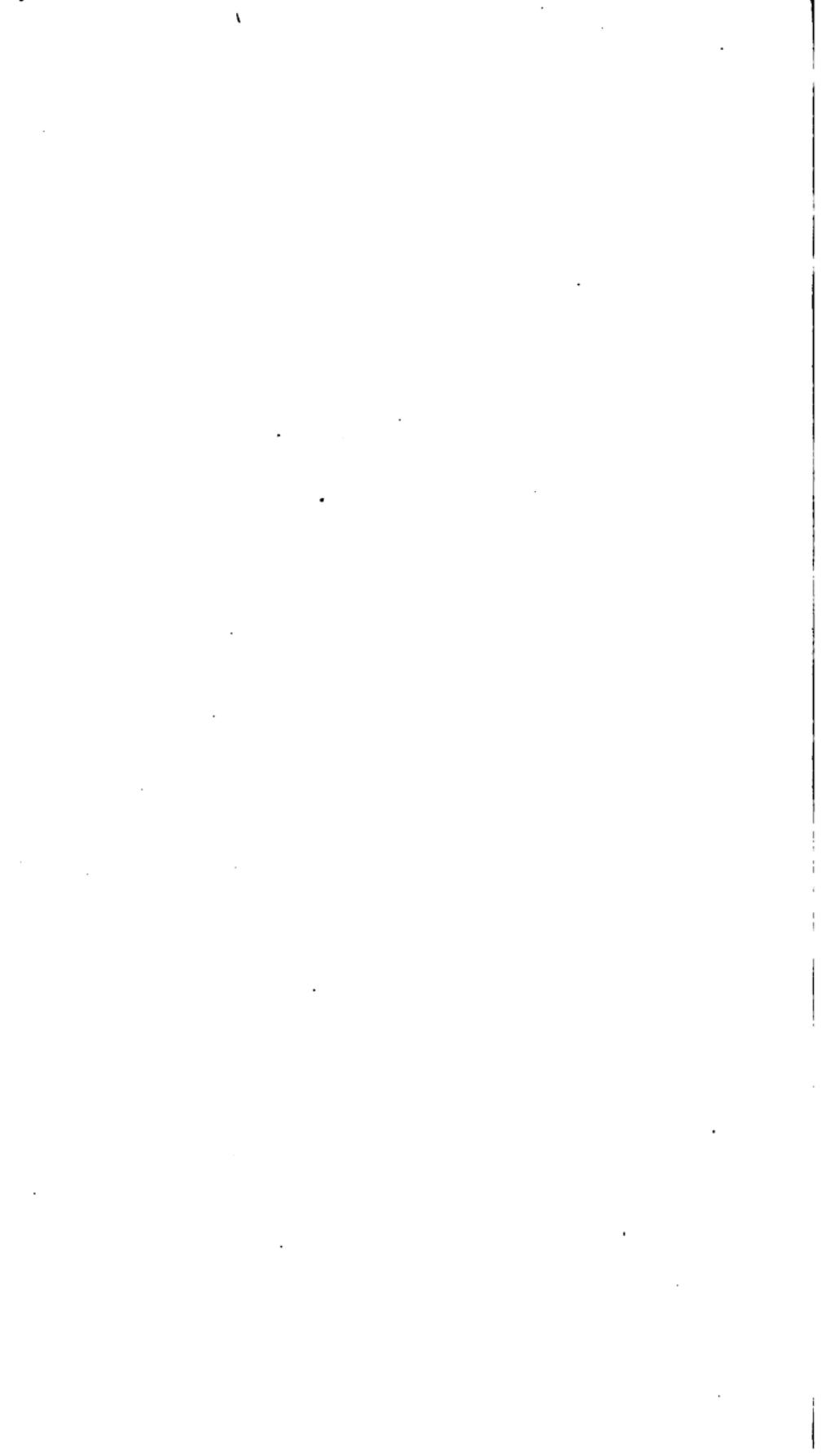








*Zheshebe
Minis*



Gift
Mrs. W. W. Bishop.
9-11-31



What boy has not stood on some meadow in the dusk and watched the fireflies pass, an innumerable caravan of mystic beings lighted by fairy candles, always burning yet never burned out? What boy has not asked his mother why the firefly's candle never is warm? has not asked his father what makes the firefly's light? And what father or mother ever could answer these questions? In actual truth no one ever was able to answer them before the month of June of the year 1915. The statement is believed to be correct—that the answers are now for the first time offered in public print.

The firefly itself has interested wise men time out of mind. There is, regarding its several species, an extensive literature in more than one language. The firefly is of widely distributed and varying species. In the

tropics children play with them, and the women of South America use strings of the cucujo—one species of the firefly—as hair ornaments. Science itself has hesitated as to the actual use of the firefly's spark. One man thinks it is given as a defense against enemies; another thinks it is used as an attraction by the female for the opposite sex. That evidently is the animating idea of the cucujo-decorated dames and demoiselles of South America.

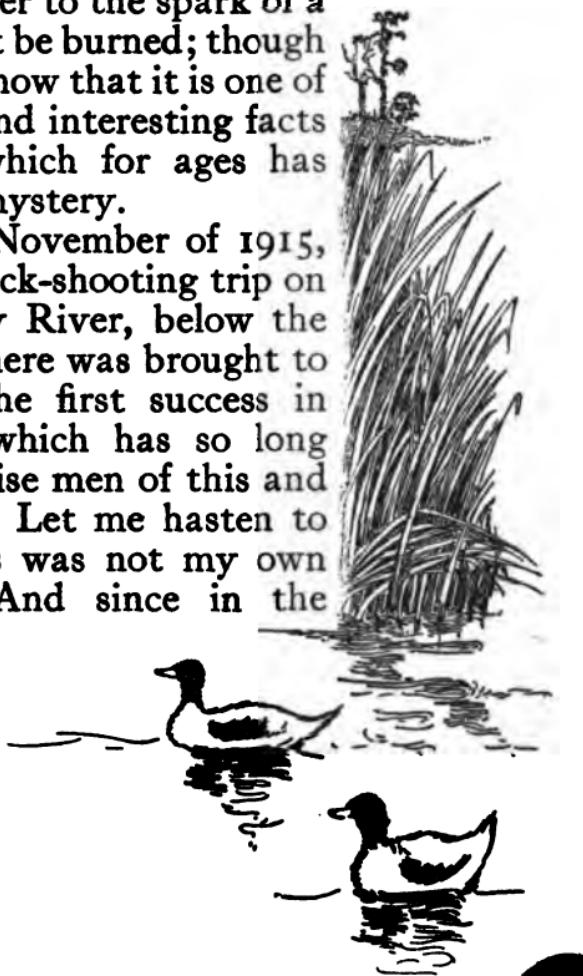
There is also in South America a large beetle that is called the railroad beetle because it has a red light at each end and a green light alongside. But no railroad man ever yet has been able to determine how it keeps its switch lights burning. The firefly's method of illumination always has been a secret process, one of Nature's trade secrets. A learned professor of Princeton where professors and presidents grow extremely wise—has long tried to solve the mystery and has failed. Thomas A. Edison

called attention to this form of illumination — himself being something of a sharp in the lighting business—but admitted that he could not make light so cheaply as the firefly, though he declared that some day man must learn its secret and employ it profitably.

All scientists agree that this strange light is the most economical ever known on land or sea. It is produced without heat and with no loss in the chemical rays. Any boy knows that he can touch his finger to the spark of a firefly and not be burned; though he does not know that it is one of the curious and interesting facts of science, which for ages has remained a mystery.

It was in November of 1915, while on a duck-shooting trip on the St. Mary River, below the Sault, that there was brought to my notice the first success in this search which has so long baffled the wise men of this and other lands. Let me hasten to say that this was not my own discovery. And since in the

[Three]



circumstances it is necessary to mention names, let me add at once that the actual and original discoverer of the source of the firefly's light is, so far as may be determined, ex-Governor Chase S. Osborn, of Michigan. It was he who was my companion on the hunt aforesaid.

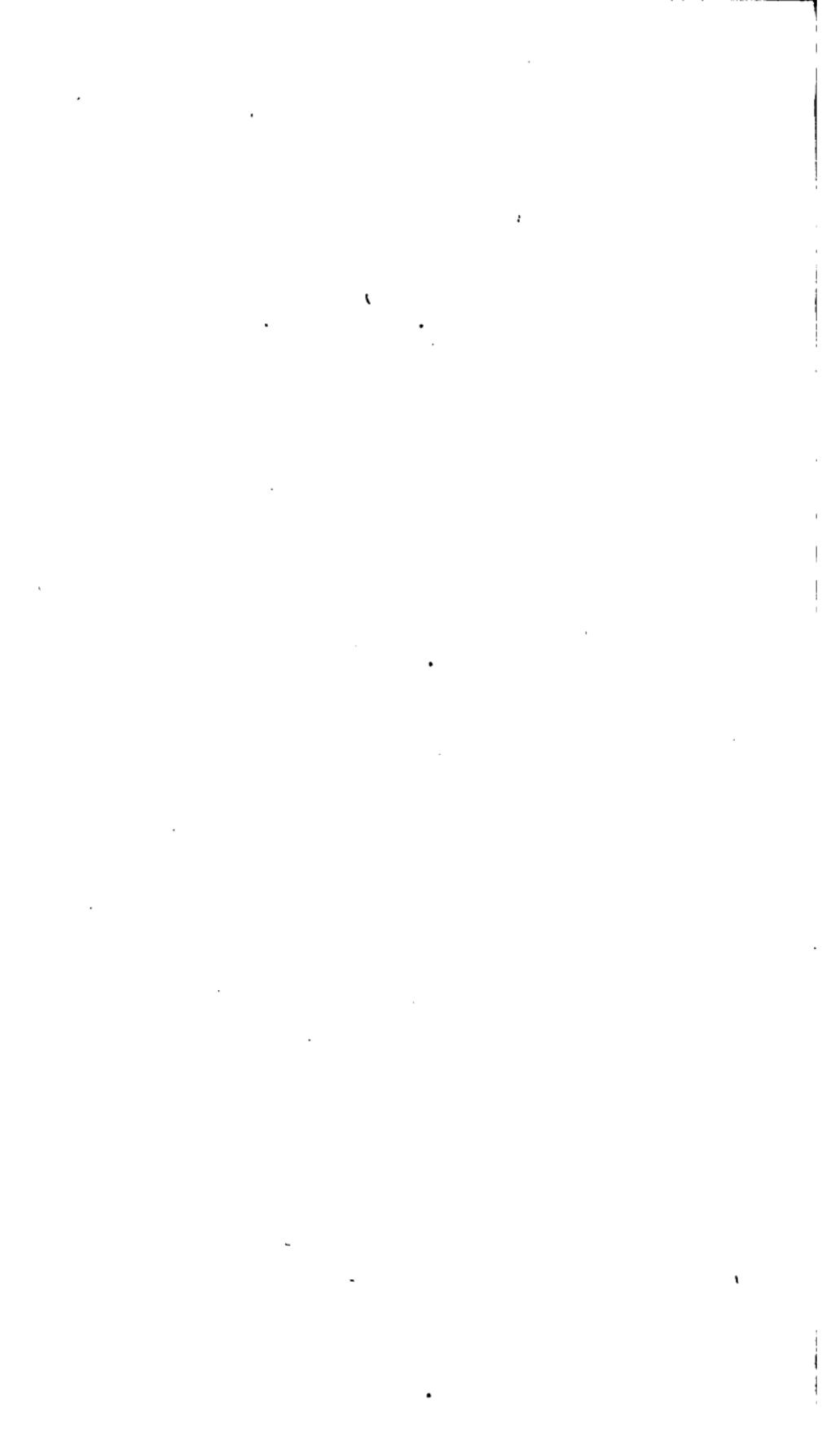
Be it said that Governor Osborn himself is naturalist, sportsman, outdoor man and traveler *par excellence*. He is the only man of my acquaintance who ever killed three African lions with a shotgun. It is said of him, no doubt truthfully, that he is the most widely traveled man in the world to-day. He has the reputation of being one of the most successful prospectors for iron ore the world has ever known; he made his fortune out of his ability to go into wild countries and fend for himself while looking for iron. Naturally, therefore, he is naturalist, student and observer, an eager questioner of Nature's mysteries.

Now Governor Osborn and I



*The
Lake
of
Purple
Shadows*





in the month of November were on a duck marsh one very stormy evening, our stations being about four miles below his hunting lodge on the shore of the great St. Mary River. A storm came up and we found ourselves in for the blackest evening either of us had ever seen on any marsh.

My companion and I were shooting a mile or so apart. As dusk approached and the storm increased I pulled up my own decoys and started for the little fire I saw he had lighted on the shore. My boatman and I picked up a dozen or so of his decoys that had blown from their moorings. It was wild work; but at last we joined him at the side of his fire on the beach.

We were four miles from home and a nasty sea was rolling, one that would swamp any little duck punt carrying two men. Joe thought he could make it back to the house alone, crawling along shore, and thus bring back the big Mackinaw boat, which would ride any sea. We agreed

to this; but meantime Governor Osborn and I also were to crawl along the shore to a certain point about half way home, where we were to meet the Mackinaw.

It was rather sloppy work in the duck boat wherever we came before the force of the wind. It now was night. The whole shore line had changed in contour. On ahead, perhaps half a mile, at length we saw a long point jutting out from shore.

"We can take our choice," said my companion—"either run outside into the sea or go ashore on yonder point. If we try that we shall probably be wrecked on a reef of rocks that runs out some distance there."

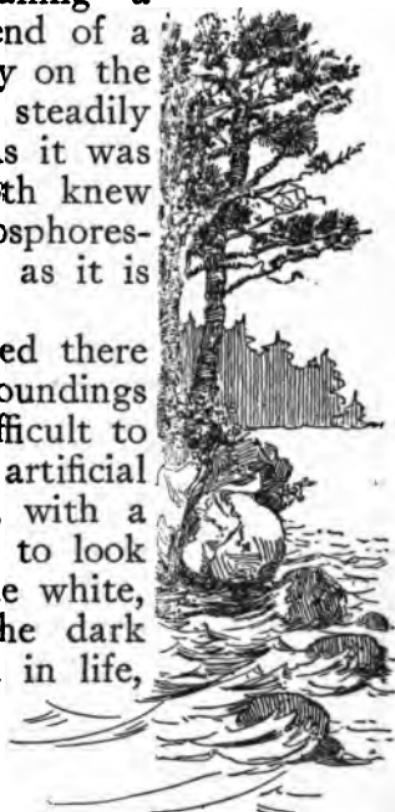
The matter being left to me, I concluded it might be better to be wrecked on the rocks than to be wrecked in the middle of the river. Whereupon, in due course, we were wrecked—but fortunately in water so shallow that we managed to wade ashore with some difficulty, dragging our boat after us.

So much preliminary to the

discovery of the source of the light of the firefly. Once ashore, Governor Osborn passed round the point, with the purpose of making another fire, which Joe could see when he came back for us with the big boat. I followed, somewhat burdened with duffle.

As I passed along the wet and slippery rocks of the narrow beach I saw, burning in the middle of the moist surroundings — for now rain was falling—a tiny spark, like the end of a match, glowing brightly on the wet ground—burning steadily and not going out. As it was late for fireflies we both knew this was a piece of phosphorescent wood, or fox fire, as it is called.

The tiny flame burned there so comfortably in surroundings which made it very difficult to kindle a fire by any artificial process that I paused, with a swift sense of wonder, to look at it as I passed. The white, wan little lamp in the dark seemed like a triumph in life,



like a success over obstacles. Governor Osborn and I talked of it for some time as we sat about our new fire which presently we managed to construct. Then he asked me whether I knew what made the light of the firefly.

"No," said I; "nor anyone else, so far as I know."

He smiled then.

"Every man," said he, "is, I presume, in search of some sort of distinction for himself. I don't know that I have done much in that line; but perhaps I have made one discovery of considerable scientific interest—indeed, of scientific importance, all things considered. By chance we have blundered on that very subject, and I can answer for you to-night a question which before last June I could not have answered—a question which all the scientific men of the world have been unable to answer before this year."

And there, sitting on a wet log in the wet night, he went on to tell me this story, which, I



*Emerson Hough—
Doctor
of
Literature*





may repeat, is thought to be the first printed explanation of the firefly's light.

"All my life," said Governor Osborn, "I have, as you know, been a student of the out-of-doors. I have traveled in wildernesses a great deal and have been obliged to learn the habit of investigation. The light of the firefly always was a curious thing to me; I always wondered over it. This summer I discovered, as I take it, the mystery of the firefly. I did this independently. It is reported to me that a French scientist has fallen on much the same line of thought. I regard his conclusions as confirmation of my own discovery.

"You perhaps do not know how much scientists have been interested in this matter of the firefly's spark. Langley and Very carried on a series of experiments comparing the light of this insect with that of the sun. They superimposed the respective spectra and found that the spectrum of the sun, with equal luminosity, extends

farther toward both the violet end and the red end of the spectrum.

"On the other hand, the light of the firefly is more intense in the green rays than is sunlight. Hence, both the heat, or red rays, and the chemical, or blue rays, practically are absent from the spectrum of the firefly. That explains the absolute economy of this light.

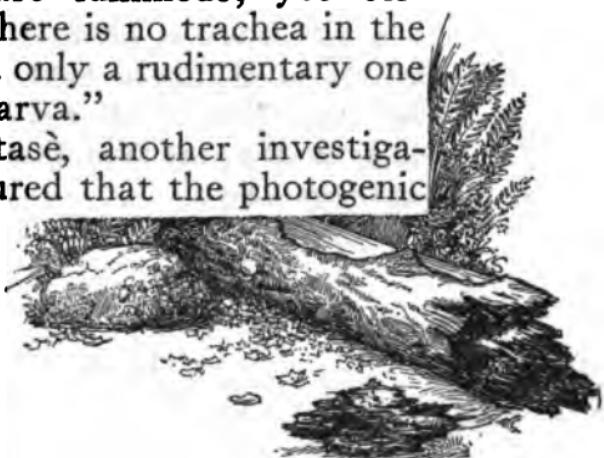
"The best electric light of today has an efficiency of only fifteen per cent. The firefly's light is one hundred per cent. efficient! It has no loss. If not perpetual motion, it seems perpetual light, and at no cost. But how can that be, since always we are told that action is equal to reaction, that light and heat work together in definite ratio, and that nothing can exist without a cause, without expenditure of energy?"

"But what I saw round the point, Governor," said I, "was not a firefly. It was simply the end of a phosphorescent bit of decayed wood."

"Precisely!" said my friend with emphasis. "That is it exactly. You have no idea how closely those two trails cross, though by mere accident. In brief, the firefly and the fox fire are the same!"

"This question of heatless light is no new thing in Nature, of course. There are luminous fishes; there is a luminous mushroom—the one known as *Agaricus*. Some scientists say there are luminous cells in the human body. But there has been endless speculation as to the source of the light of fireflies. Lang, Emery and Wielowiejsky thought it came from combustion of oxygen in the minute capillaries of tracheæ that supply the luminous organ of the firefly; but these men were wrong. It is not the product of combustion at all, because some of the larvæ are luminous; yet certainly there is no trachea in the egg and only a rudimentary one in the larva."

"Watasè, another investigator, figured that the photogenic



material is a product of metabolism in the cell; that the process of its formation is identical with that known as secretion. He declares that there may be secretion without the existence of a special gland; that the fundamental process may be carried out by a single isolated cell just as well as by thousands of cells constituting a gland. Very well; but the mystery remains just as before. No biologist has ever found an organ of any size in the firefly that has for its function the secretion of its light.

"Now a French biologist, Goureau by name, has proved that the firefly deposits its eggs in decaying wood, where they remain for five years. I do not know whether we may call his or my own the original discovery of the light of the firefly—rather, I prefer to call each complementary of the other and the two constituting a perfect theory. Goureau deduces nothing from his discovery; he simply says that fireflies do this, but he does not say why.

"Yet another Frenchman, Dubois, says that he considers the firefly's light to be due to two substances—luciferase and luciferin. He proves to his own satisfaction that luciferase is an enzyme, which he has found in the form of minute granules in the thorax of the firefly. He asserts, it seems to me without much evidence, that luciferin exists in the blood and becomes luminous only when it is carried into the luminous organ of the firefly; but he does not discover the mechanics of this operation. Indeed, there is no such thing as mechanics about it.

"We may mark Dubois off the slate as not independently successful in his search for the source of the light of the firefly. Goureau is more useful to us. We should, indeed, remember them both and in connection—we must remember Goureau discovered that firefly eggs are deposited in decaying wood for five years, and we must remember that Dubois discovered enzymes in the thorax of the

firefly. Now then for what I think I may justly call my own discovery.

"Last June, on a very dark and humid night, I broke open a decaying log, twelve feet long and a foot in diameter, on Duck Island, here in the St. Mary River. One end of the log was unbrokenly incandescent with that illuminant commonly called fox fire. The other end of the log, for five or six feet, seemed to contain myriads of minute luminous particles, which appeared in the moonless darkness as miniature stars. On more careful observation these stars were found to be firefly larvæ.

"At once I concluded that the purpose of the firefly in depositing its eggs in the decaying wood—to remain there five years, as discovered by Goureau—was to enable the process of catalysis to reach the point of perfection where the light caused by it might be transferred to the firefly."

By this time, though it was a very cold night, I was sweating

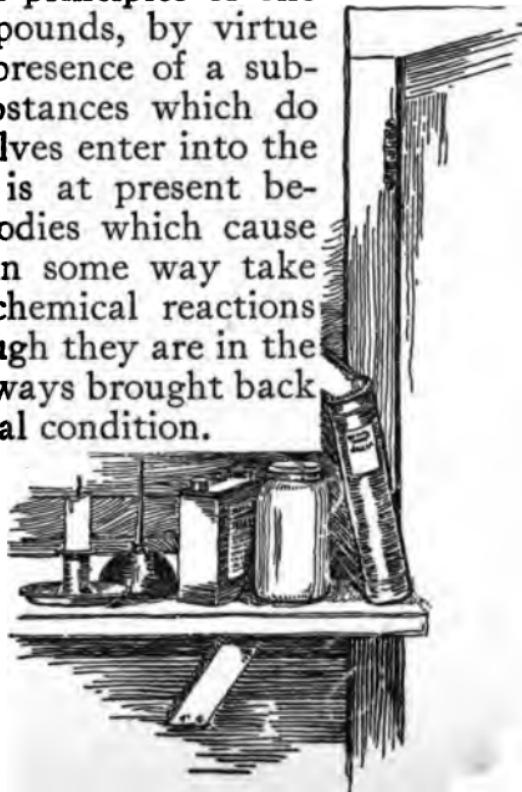
hard in my attempt to follow the rapid dictation of my companion at the other end of the wet log.

"My dear Governor," I said to him, "is there such a thing as a dictionary at the camp?"

"Sure!" said he. "You will find it behind the door, with the gun grease."

I later did so, and therein discovered the following definitions of one or two words that cannot well be left out of the story:

Catalysis: 1. Dissolution, destruction, degeneration, decay. 2. A decomposition and new combination, supposed by Berzelius and other chemists to be produced among the proximate and elemental principles of one or more compounds, by virtue of the mere presence of a substance or substances which do not of themselves enter into the reaction. It is at present believed that bodies which cause catalysis do in some way take part in the chemical reactions involved, though they are in the course of it always brought back to their original condition.



"Enzyme: Any of the unorganized ferments, such as diastase, maltin, pepsin, trypsin, and so on, which exist in seeds," and so on.

Of course, as I did not get to the dictionary for a couple of hours, my perspiration remained unabated; but I told the gentleman on the other end of the wet log to go ahead and I would do the best I could in the dark. So he continued:

"Phosphorescence in wood is caused by catalysis. Catalysis is the work of the enzyme. Enzymes have been discovered in the firefly by Dubois. The enzyme is the agent of transference of the phosphorescent light of the wood to the firefly.

"Many of the functions of enzymes are known. Their limitation is not known. No one knows just how the enzyme performs its functions or how many it has. It is known to be a catalytic agent, causing dissolution, degeneration, decay, though remaining unchanged itself. The contact process of making sul-



*The Man
on the
Other End
of the Wet Log*



phuric acid is the work of enzymes. The transformation of starch into sugar in the human body is the work of enzymes. The distribution in the human system of monosaccharides, which have been created by the enzymes, is their work. They are everywhere in life, both in the vegetable and animal world. It may even be that they are the source of life itself. The discovery of the enzyme has solved many scientific mysteries.

"In the end of the log that I burst open, where there were no firefly larvæ, the phosphorescence was complete. In the end of the log where the larvæ were deposited there was no phosphorescence except in the larvæ, indicating the absorption of it by them.

"A certain number of the enzymes that have been at work in the catalytic process of producing phosphorescence in the wood transfer themselves to the firefly and keep up the work as long as the firefly has life and there is material. A definite mass of

enzymes produces a definite but very, very large amount of transformation, as is proved by the contact process of making sulphuric acid and in other practical directions.

“Enzymes are already so useful in chemical engineering that it would seem to be entirely possible to inoculate ligneous substances, wood and peat, with them and produce the light of the firefly for economical human use. Nature’s processes in this realm are very slow. It will be for inventive man to hasten them and harness them, as has been so often done in other channels. The raw material for enzymic light is waste material, ✓ and the great percentage of cost would be the expense of the process, whatever that might be.

“At present, phosphorescence in wood requires months and years to create. The enzyme, which is the catalytic agent producing the necessary conditions of ligneous decay and transformation, is not present in great enough numbers. An ad-

ditional supply of enzymes would do the work in days where months are now consumed."

Far off, a mile or more down the river, a speck of light now appeared, moving fitfully, like a firefly in the gloom. Joe was coming with the Mackinaw. The wind was screaming over the trees that lined the point back of which we huddled over our own bivouac fire—a fire which carried heat but which meant much waste.

We sat for a time silent, looking at the little spark of light out on the wild river. In a purely whimsical way there came to my mind the old family doctor's explanation of another mystery of the boyhood soul: Whence came the new baby they showed to us? They told us the doctor found it in a hollow log. Maybe! Maybe!

It is not a mad world, my masters, but a strange, kindly, interesting and generous world, this of the out-of-doors. It holds many secrets for us only to interest us; but at the last it yields



them up if only one shall seek sufficiently and always with much patience.

And how saith the poet—that there are sermons in stones? See what one outdoor man at least found in a hollow log! Was it life itself? In any case I felt there had been a certain symposium when at length we scattered the embers of our fire on the beach and took ship in the big Mackinaw for our tempestuous voyage home.

Governor Osborn later cautioned me not to accord to him any position of vaunting in this matter of his own chance discovery.

"You will remember," said he, "that in the case of Watt's 'discovery' of steam it was not a discovery at all, but simply a correlation of facts that he made. The same is true of the development of the locomotive by Stephenson; it may be said to be true of almost every discovery that is made. One man discovers one thing, one another; and finally somebody discovers

the missing link, the key. Then the facts are correlated and the conclusion is satisfactory.

"My idea is at least new and I think it is indisputable. Those to whom I have submitted it are as firm in their conviction as I myself am.

"The remarkable fact that Goureau has proved—that the fireflies lay their eggs in wood, where they remain five years—must mean something. The other disconnected fact that Dubois has discovered enzymes in the firefly is, to me, wonderful. That these things and others bearing on the subject have not been connected is not surprising, because the enzyme itself is of very recent discovery.

"The result of my observations satisfies me that firefly light is catalytic. Enzymes are the catalytic agents. They perform the most wonderful feats in all the realm of life. It is not more remarkable that they should create the phosphorescence in wood, as it is agreed by scientists

they do, than that they should transfer it to the firefly.

"Nor is this function more remarkable than the work they do in the human body, which is by no means confined to the transformation of starch into sugar, and so on. If they can be used in making sulphuric acid it ought not to be impossible for them to be used in producing great volumes of the light they create in so small a way in the firefly.

"To come back again to the practical side, wherever ligneous material of waste character or otherwise exists, it could be used in producing commercial light. This idea is not farther fetched than the wireless telephone or many other of the wonderful things that have been done."

So the scientists worked in their laboratories, with their microscopes and test tubes, for years and years, studious, bespectacled, grave and gray and pale. And meantime it was left for a red-blooded outdoor man to open a hollow log by accident with his axe and find out more in



*Rippling
Waters
and
Spicy
Shores*

